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## *Humans: the party animal*

By definition, the species *Homo sapiens* is unique. Over a time course of approximately seven million years, humans have evolved into quite a different animal from what was the last common ancestor we share with our closest surviving relative, the chimpanzee. Trying to figure out how we came to be what we are, and identifying what aspects, both physical and behavioral, we share with other animals, most especially the chimpanzee, and those that are uniquely human has been of ongoing interest.<sup>1</sup>

Take a minute the next time you go to a dinner party, barbecue, wedding reception, or baby shower – run-of-the-mill events for us *Homo sapiens* – to ponder the fact that such events are completely unheard of in any other species. What other animal would plan an event, provide food to unrelated others, and sit together and share it without a food fight, all while laughing about stories of the past and hopes and dreams of the future? There is none. No matter how smart your family dog may be, he would not divvy up a prime rib roast and pass it out to the other dogs of the neighborhood with a happy little bark; neither would our closest relatives, the chimps. Humans are social beings, and although

there are other animal and insect species that are social, our species takes sociability to a previously unknown level. We are party animals, and on our way to becoming such we have evolved a whole host of unique features – features so unique that we humans are playing in another ballpark.

Although many may suggest that humans act “like a bunch of animals,” and the daily news intimates that we are endlessly fighting with one another, it is by cooperating with and helping unrelated others that we are unparalleled among animal species. Something is markedly different in our brains: we are “wired” differently. The results of this altered wiring allow humans to read books, or to go to the symphony, school, or jail. That is not to say humans are 100 percent different. In fact, most of our automatic processing is much the same as in other animals.

Although all species are unique unto themselves, all have a common origin and are made up of the same materials. It isn't surprising that when Charles Darwin first proposed that humans were descended from the great apes, he thought that the difference between us and our closest relatives, the chimpanzees, was a quantitative difference, not a qualitative one. We were just fancier apes with bigger brains, Darwin rea-

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soned. In the mid-1960s, however, Ralph Holloway added to Darwin's theory, concluding that brain reorganization, rather than brain size alone, resulted in the evolutionary changes in cognitive capacity. Evidence for Holloway's insight is accumulating.

What exactly is brain reorganization, and how has it affected brain computations and the human mind? Cognitive scientists Derek Penn, Keith Holyoak, and Dan Povinelli, "happy to be the hostage[s] of empirical fortune,"<sup>2</sup> claim:

The profound biological continuity between human and nonhuman animals masks an equally profound functional discontinuity between the human and nonhuman mind. . . . [That discontinuity] pervades nearly every domain of cognition – from reasoning about spatial relations to deceiving conspecifics – and runs much deeper than even the spectacular scaffolding provided by language or culture alone can explain.

This "discontinuity of human cognition," they propose, was a watershed change that occurred after the hominid line diverged from our last common ancestor with the chimp, and it resulted in our exceptional relational ability. We far exceed other species in our ability to grasp analogies and to combine relations into higher-order structures. Mindful that there are no "unbridgeable gaps" in evolution, figuring out how this came to be is the question. Regardless of whether or not our ability to form higher-order relations is the basis for our cognitive differences, something very different is going on in the human brain.

There is no question that the human brain is big. After the hominid line diverged from the last common ancestor we share with the chimps, the brain underwent a huge growth spurt. In com-

parison to a chimp's brain, which weighs about 400 grams, an average human brain weighs about 1,300 grams. *Homo neanderthalensis*, however, had a bigger brain than modern-day humans, and although it is clear through fossil evidence that their culture was more advanced than that of the chimp, they were not in the same league as *H. sapiens*. Thus brain size is not the only variable in human uniqueness.

In non-primate mammals, the brain's prefrontal cortex has two major regions that work together to contribute to the "emotional" aspects of decision-making. We do, of course, make many of our decisions quickly and based on our emotions, and so still utilize these two evolutionarily older regions. However, some decisions are based on rational thinking. Only primates possess a third, evolutionarily newer region, the lateral prefrontal cortex, where the intriguing Brodmann Area 10 is located. One hundred years ago, German neurologist Korbinian Brodmann identified fifty-two distinct regions of the human cerebral cortex, based on the underlying cytoarchitectonics. Area 10 in humans is disproportionately larger compared to the rest of the great ape brains, and is densely interconnected with other still larger regions in human brains. Area 10 is concerned mainly with the "rational" aspects of decision-making and is involved with all sorts of abilities in which humans excel: memory and planning, cognitive flexibility, abstract thinking, initiating appropriate behavior and inhibiting inappropriate behavior, learning rules, and picking out relevant information that is perceived through the senses.

The posterior parietal cortex is another disproportionately enlarged area. One of our hominid ancestors, *Australopithecus africanus*, displayed the first signs of enlargement of this cortex, the part of

the brain active when objects are manipulated and motor activities are planned. Also disproportionately large are the connective pathways of the temporal lobe, indicating increased local connectivity between neighboring cortical fields, which support the formation and processing of declarative memory; self-recognition; visual, auditory, and language processing; and the detection of biological motion.<sup>3</sup>

Neurobiologist Georg Striedter suggests that the human brain has not enlarged randomly, but that an entire circuit that has made humans more flexible and capable of finding novel solutions to problems has enlarged. Perhaps one of the most important abilities included in this circuit is that of inhibiting automatic response, which is notoriously difficult or impossible for other animals, including our chimp relatives. Only with this ability can one respond in novel ways, and utilize the cognitive flexibility that we uniquely possess. (These systems are not fully developed in adolescent humans, offering a possible explanation for their impulsive ways.)

When brain size increases, what actually increases is the number of neurons, their width, and their connections. In general, the larger the area, the better connected it is. Each neuron, however, can connect to only a limited number of other neurons, a number that does not change as the overall number of neurons increases. As absolute brain size increases, proportional connectivity tends to decrease, and the internal structure changes as the connectivity pattern changes. In turn, less dense connections force the brain to specialize, create local circuits, and automate. The human brain has billions of neurons that are organized into local, specialized circuits, known as modules.

Over the last several years, we have also learned of many specialized brain functions that are lateralized in the human brain. This means that one hemisphere of the brain may perform a specific function that the other hemisphere cannot perform. The first hint of human lateralization of function came in 1836, when a French neurologist observed that three of his patients that had lesions of their left hemispheres had speech disturbances. Twenty-five years later, Paul Broca, after studying the postmortem brains of aphasic patients, concluded that the speech center was located in the left hemisphere. There are some anatomical asymmetries to be found in the non-human primates and, more notably, in the great apes; however, there is scant evidence for lateralization of function in other mammalian species. The corpus callosum, the great track of neurons that transmits information from one hemisphere to the other, may have provided the evolutionary innovation that allowed cortical capacity to expand. Without increasing brain size, it allowed mutations leading to innovations in one half of the brain, while preserving cortical function in the other half. There are also microscopic asymmetries in the cellular organization of the neocortex that have not been found in other species and are thought to be uniquely human.<sup>4</sup> Clearly, our brains are physically different. It should come as no surprise, therefore, that they also function differently.

Our brains and abilities evolved because our bodies evolved along with them: changes in one happened in concert with changes in the other. Between five and seven million years ago (some recent studies suggest that it may have been more than ten million)<sup>5</sup> we shared our last common ancestor with the

chimpanzee. For some unknown reason, most likely climactic changes resulting in a change in the food supply, the hominid line split. The branch of the family that produced the chimps stayed in the tropical forest and remained much the same. The other branch stepped out into the woodlands, where life was quite different, evolving to become bipedal and, over time, undergoing a host of other changes as well that have led to our current abilities.

Particularly important among the anatomical results of bipedalism are our elongated necks and the fact that our tongue and pharynx dropped lower down into the throat. Unlike the chimps that have two separate passageways for food and air, we developed a unique system, in which air and food share a common pathway in the back of the throat. We have a structure, the epiglottis, that closes the pathway to the lungs when we swallow and opens when we breathe. The unique anatomy of the pharynx, specifically the larynx, enables us to utter the wide variations in sound that we can and makes speech possible. No doubt, the survival advantage we gained was an increased ability to communicate, even though we face an increased risk of death by choking. Bipedalism also set our hands free, and our thumbs became unique. Both humans and chimps have opposable thumbs; chimps, though, don't have ulnar opposition: they can't arc their thumbs across to their baby fingers. Hence, we can pick up objects with the tips of our fingers, not with just the sides, as chimps do. We also have more sensitive fingertips, with thousands of nerves per square inch that send information to the brain.

One major physical problem presented by bipedalism was a smaller pelvis, and thus birth canal. (A wider pelvis would have made bipedalism mechanically im-

possible.) Birth became more difficult as brains and heads enlarged. In comparison to other apes, human babies are born one year prematurely, and, unlike chimps, their heads and brains continue to grow for several years.

From our current viewpoint, bipedalism seems only advantageous; yet the late psychologist Leon Festinger saw the proverbial fly in the ointment. He pointed out that "bipedalism, in and of itself, must have been a nearly disastrous disadvantage,"<sup>6</sup> making us slower and less able to climb, and its evolution needed a special explanation.

Before we leave Festinger's bipedal quandary, we should pause to consider a study done by the evolutionary biologists Willem de Winter and Charles Oxnard. Rather than looking at overall brain size, de Winter and Oxnard suggested that a brain part's size is, to a certain extent, related to its functional relationships with other brain parts. Using brain-part ratios from 363 species, they ran multivariate analyses, with fascinating results. Groups emerged based on similar lifestyles (locomotion, foraging, and diets), rather than on phylogenetic relationships. For instance, New World insectivorous bats had brain-part ratios more closely linked with Old World carnivorous bats, rather than with their phylogenetically closer relatives, the New World fruit eating bats.

The primates fell into three groups, also based on lifestyles that cut across phylogenetic lines: those with hind-limb-dominant locomotion; the four-limb dominant; and the upper-limb dominant – those that hang from branches while eating, reach above their heads for fruit, and escape by upper-limb acrobatic activities. (This group included chimps and gorillas, along with the phylogenetically distant spider and wooly monkeys.)

Oxnard's analysis revealed that the species within a lifestyle group had similar brain organizations: that the convergence and parallels in brain relationships are most likely associated with convergences and parallels in lifestyles that cut across phylogenetic groups. Humans, however, the only species of the 363 studied that have a bipedal lifestyle, fell into a group unto themselves, with a highly significant 22 standard deviation difference between them and chimpanzees. Oxnard concluded, "The nature of human brain organization is very different from that of chimpanzees, which are themselves scarcely different from the other great apes and not too different even from Old World monkeys."<sup>7</sup> Something about the human bipedal lifestyle is related to our very different brain organization.

Festing suggested that the primary factor allowing this "seriously handicapped species" to survive was an inventive brain and neural system that could figure out just what to do with those appendages that would be fruitful and adaptive. But perhaps it was the disadvantage of being slower that later resulted in so many cognitive changes. The open woodlands were a radically different environment. Food sources were highly scattered, and although there were more animals for our ancestors to hunt, there were also more animals hunting them. And just when our ancestors were being exposed to bigger and more dangerous predators, they could no longer run as fast or climb as well. There are two ways to discourage predators: either be bigger and faster than they, or live in a larger group. Unable to choose the former, the early hominids banded together in large groups not only to provide better protection, but to make both hunting

and gathering more efficient, thus providing more food for the growing brain.

Over the years there have been many suggestions as to what forces were driving the relentlessly enlarging brain. It is coming to be accepted that, through the process of natural and sexual selection, two factors were pushing the increase in overall brain size: a diet that provided the added calories needed to feed the metabolically expensive bigger brain; and the challenges originating from living in those large groups – "the social world" – necessary to guard against predators.

Many proposals have been tendered as to what diet provided the necessary amount of calories to feed that metabolic furnace of a growing brain. Richard Wrangham, a primatologist who has studied chimpanzees in Uganda for over thirty years, suggests that *Homo sapiens* are uniquely biologically adapted to eat cooked food, and that cooked food, which has more calories than raw food and is faster to eat, drove the expansion of the brain by increasing calories and decreasing the amount of time and energy it takes to ingest and digest them – in turn freeing up more time for hunting and socializing. And, as the saying goes, free time is the devil's playground.

Banding together in social groups for protection against predators presents its own set of problems, such as competition with conspecifics for resources (both food and prospective mates). Thus the cognitive challenge of surviving in increasingly larger social groups was likely the other driver of increasing brain size, as psychologists Richard Byrne and Andrew Whiten suggest. Their proposal, now dubbed the Social Brain Hypothesis, states:

Most monkeys and apes live in long-lasting groups, so that familiar conspecifics



are major competitors for access to resources. This situation favours individuals that can offset the costs of competition by using manipulative tactics, and skillful manipulation depends on extensive social knowledge. Because competitive advantage operates relative to the ability of others in the population, an “arms race” of increasing social skill results, which is eventually brought into equilibrium by the high metabolic cost of brain tissue.

Successfully living in social groups involves more than competition; it also involves cooperation. Very recently, developmental and comparative psychologists Henrike Moll and Michael Tomasello proposed the Vygotskian Intelligence Hypothesis. They assert that although cognition in general was driven mainly by social competition, the unique aspects of human cognition – the cognitive skills of shared goals, joint attention, joint intentions, and cooperative communication needed to create such things as complex technologies, cultural institutions, and systems of symbols – were driven, even constituted, not by social competition, but social cooperation.<sup>8</sup>

Anthropologist and evolutionary biologist Robin Dunbar has been searching for social and ecological indices that correlate with primate brain size. He has found five aspects of social behavior that correlate with brain size, the first of which is social group size: the bigger the neocortex, the larger is the social group. The great apes require a bigger neocortex per given group size than other primates, indicating that the social milieu of the great apes is more cognitively taxing. Dunbar’s research has shown that the factor limiting social group size is the ability to manipulate and coordinate information and social relation-

ships. The other social skills that he has correlated with brain size are the number of individuals with whom an animal can simultaneously maintain a cohesive intimate relationship; how much social skill is required in male mating strategy; the ability to manipulate others in the social group without the use of force; and the frequency of social play.

While a chimp maxes out juggling a social group size of about 55 individuals, Dunbar has calculated from the brain size of humans that we have a social group size of about 150. Initially this seems rather surprising when you think of the huge cities that many humans inhabit; but when you look more closely, it begins to make more sense. One hundred fifty individuals is the typical size of hunter-gatherer clans, also the typical number of individuals on a modern-day Christmas card list or in military units and businesses that can be run informally. It appears to be the maximum number of people an individual can keep track of and for whom he would be willing to do a favor. And the extent to which humans do favors is unique.

Doing favors is altruistic, and Darwin himself could never quite figure out how it occurred through natural selection. Why would an individual do anything that would increase the survival of another to his disadvantage? The late William Hamilton, an evolutionary biologist, realized that altruistic behavior could evolve if the benefiting individuals were genetically related to the provider, because helping one’s close relatives survive and reproduce also passes your genes on to the next generation.

Humans, however, help unrelated others all the time. We are the superlative Helpful Henrys of the animal world, and this behavior has its foundations in

reciprocal altruism, first described by sociobiologist Robert Trivers. If an individual does a favor for an unrelated individual and is sure it will be returned at a later date, then that could provide a survival advantage. Reciprocal altruism is very rare in the animal world, and several problems have to be overcome in order for it to work. First, the commitment problem: how could any individual be sure (trust) that the favor would be returned? Second, an individual has to be able to recognize another individual specifically; third, he has to be able to remember a favor was done and what it was; fourth, he has to live in close enough contact that predictable occasions will arise for reciprocation; and fifth, he has to be able to evaluate the cost of his favor and make sure he gets one back of equal value. Marc Hauser, a professor of psychology and evolutionary biology at Harvard University, thinks that our impressive mathematical abilities evolved with the emergence of social exchange systems. However, because there is a time lag between the completion of a favor and its reciprocation, cheating can occur. Not surprisingly then, a species that practices reciprocal altruism has mechanisms to identify cheaters. Evolutionary psychologist Leda Cosmides has developed a test that indicates that the human mind has a specific module that detects individuals who cheat in social exchange situations. She has found that cheater detection develops at an early age, operates regardless of experience and familiarity, and detects cheating, but not *unintentional* violations.

Identifying cheaters is only half the job. Game theory researchers have shown that for prolonged social reciprocity to exist, not only must cheaters be detected, but they also must be punished; otherwise, cheaters, who invest

less but receive an equal benefit, will out-compete the non-cheaters and take over. If cheaters take over, no one foots the bill and reciprocity crumbles. Humans have evolved two abilities that are necessary components for *prolonged* reciprocal social exchange and are on the short list of uniquely human capacities: the ability to inhibit actions over time (a.k.a. delayed gratification) and punishment of cheaters in reciprocal exchange.

The importance of reciprocal exchange should not be understated. Cosmides observes, "As humans, we take for granted the fact that we can help each other by trading goods and services. But most animals cannot engage in this kind of behavior – they lack the programs that make it possible. It seems to me that this human cognitive ability is one of the greatest engines of cooperation in the animal kingdom."<sup>9</sup> Moll and Tomasello think that the unique aspects of human cognition were driven by social *cooperation*.

Indeed, cooperation is rare in our chimp relatives, and recent studies show that it only happens in competitive situations, and only under certain circumstances with certain individuals.<sup>10</sup> Brian Hare and Michael Tomasello suggest that the temperament of the chimp constrains his behavior, and that the human temperament might be necessary for the evolution of more complex forms of social cognition. Before hominids were able to work cooperatively, they had to become less aggressive and competitive and more tolerant and friendly with one another.

Hare and Tomasello suggest that this may have been achieved by a kind of self-domestication process that selected for systems that controlled emotional reactivity, such as aggression. Perhaps individuals in a group would either ostracize or kill overly aggressive or des-

potic others. Dubbed the “emotional reactivity” hypothesis, it is based on continuing studies done by geneticist Dmitry Balyaev, who began domesticating foxes in Siberia in 1959 by selecting only for a single criterion: whether they exhibited fearless and non-aggressive behavior toward humans. In other words, he selected for fear and aggression *inhibition*. The experimentally domesticated foxes are as skilled at using human communicative gestures – pointing and gazing, for example – as domestic dogs.<sup>11</sup> These results suggest that sociocognitive evolution has occurred in the experimental foxes as a correlated by-product of selection on systems mediating fear and aggression. Dog domestication is thought to have occurred by a similar process. Wild dogs that were less fearful of humans were the ones that approached them, stuck around, and reproduced.

Reciprocal exchange is not only an engine of cooperation, it is one of the driving forces behind our innate morality. Many researchers studying morals and ethics propose that we have “ethical” modules. These modules have been derived from the common emotions and the behaviors they engender, which we share with other social species and which include being territorial; having dominance strategies to protect territory; forming coalitions to garner food, space, sex; and reciprocity. These modules have evolved to deal with specific circumstances, common to our hunter-gatherer ancestors, that involved what we now consider moral or ethical issues.

An environmental trigger activates these modules, which induce an automatic judgment of approval or disapproval. If the trigger is strong enough, a moral emotion is elicited. The emotional state produces a moral intuition

that may motivate an individual to action. We share many of our so-called moral intuitions with other animals. Humans differ by way of the *reasoning* about the judgment or action that comes *afterward*, as the brain seeks a rational explanation for an automatic unconscious reaction. This is when the uniquely human left brain’s interpreter device (see below) provides an explanation for the moral emotion, intuition, and the action. Also unique to humans, some moral emotions can evidence themselves in blushing or tears, and are difficult to counterfeit. As a result, these behaviors are a good advertisement that an individual has a conscience or is compassionate. Such visual proof of a moral emotion can indicate that the individual would be trustworthy and a good partner for reciprocal exchange.

It appears that the moral emotions of shame, embarrassment, guilt, disgust, contempt, sympathy, and compassion are also uniquely human. Moral emotions solve the commitment problem presented by social exchange and allow the first move. Jonathan Haidt, a social psychologist, points out that moral emotions aren’t just for nice guys, and this is a very important point. Some moral emotions can also lead to ostracism, shaming, and murderous vengeance. Oddly enough, it may be that those moral emotions are what actually made us nicer: moral emotions motivate the punishment of cheaters, which is necessary to sustain reciprocity and cooperation. Perhaps they were part of the self-domestication process proposed by Hare and Tomasello. We know that our relatives the chimps understand intention and are vengeful. In experiments with humans, chimpanzees will become more upset when a human intentionally interrupts a feeding ses-



sion, than when he accidentally does<sup>12</sup> and will retaliate against personally harmful actions.<sup>13</sup>

But all this does not explain why people will leave a tip in a restaurant that they will never return to, or why people will cooperate with unknown others or sacrifice for non-kin. Haidt suggests that sociologist Emile Durkheim's insight, that morality binds and builds groups, can answer this question: "Morality constrains individuals and ties them to each other to create groups that are emergent entities with new properties." He suspects that reciprocal altruism is supplemented with a type of "indirect reciprocity." Here, it pays to be virtuous by following the morals of the community, because such behavior enhances your reputation or status, and rewards you with increased future cooperation.<sup>14</sup>

Certain abilities are necessary to feel the uniquely human moral emotions:

- In order to feel sympathy and compassion, one must understand that another has feelings, and be able to identify them and take another's perspective, which requires inhibiting the default mode of self-perspective.
- In order to feel the "self-conscious" emotions of guilt, shame, and embarrassment, one also has to be self-aware and conscious of these emotions.
- In order to cooperate with another, one must share intentions, attention, goals, and possess Theory of Mind, the understanding that the other has beliefs, goals, and intentions. Once again, in order to enact this suite of behaviors, one has to inhibit self-perspective.

**H**ow might this all work in the brain? Many neuroscientists think that the so-called mirror neurons are fundamental for the development of self-awareness,

Theory of Mind, and language, and there are those who think the neurons were fundamental for human consciousness. Scientists studying macaque monkeys discovered these premotor neurons, which fired both when a monkey observed or heard another manipulating an object with his hand or mouth and when he himself manipulated an object. Mirror neurons are the first concrete evidence of a neural link between observation and imitation of an action. Subsequently, more extensive mirror neuron systems have been described in the human, where they are not restricted to just hand and mouth movements, as in the monkey. They correspond to movements all over the body; in fact, the same neurons are active even when we only imagine an action.

Mirror neurons are implicated not only in the imitating of actions, but also in understanding the intention of actions. Humans also appear to have mirror systems in the insula involved with understanding and experiencing the emotions of others, mediated through the viceromotor response. Such systems, by unconsciously internally replicating actions and emotions, may be the mechanism behind what gives us an implicit grasp of *how* and *what* other people feel or do, and contribute input used in our theorizing about the reason (the *why*) for the actions and emotions of others. Giacomo Rizzolatti, who first discovered mirror neurons, and Michael Arbib, director of the University of Southern California Brain Project, suggest that the mirror system was fundamental for the development of speech and, before speech, for other forms of intentional communication, such as facial expression and hand gestures. Mirror neurons also serve to synchronize our feelings and movements with those of others around us: for example, everyone in the

audience claps in unison to bring the performer back out for one more rendition of their favorite song. Mirror neurons are one of the psychological mechanisms that create group cohesion.

But if the same neurons are active when I observe an action as when I perform the action, how can I tell who has done it? Beyond the shared neural networks that are active in both cases, when we take a personal perspective, parts of the somatosensory cortex, the part of the brain with specific areas that map to specific parts of the body, are also active. When we take another's perspective, however, we activate one area of the temporal parietal junction that has input and output connections with many parts of the brain and plays a part in differentiating self from other, as well as a part of Area 10 in the prefrontal cortex. The activation of Area 10 is what inhibits self-perspective; damage to the area can lead to excessively egocentric behavior. It has been suggested that errors in assessing another's perspective are a failure of suppressing one's own. Inhibiting our own perspective gives us flexibility to take another's, and although chimps appear to be able to do it to a limited extent (even then only while in competition), humans can do it voluntarily without constraints.

Neither reality nor visibility constrains humans. We can feel an emotion through abstract input, such as reading, or by merely imagining it. The emotion of disgust activates the same brain circuitry (the operculum) whether one is experiencing it oneself or observing or imagining the disgust of others. The output of this region, however, is connected to the rest of the brain in a modality *specific* way, so these modalities feel different.<sup>15</sup>

Complex social interactions depend on our ability to understand the mental

states of other people. Having a Theory of Mind (ToM), also known as "intuitive psychology," is our intuitive understanding that others have invisible states – beliefs, desires, intentions, and goals – that can cause behaviors and events. Some cognitive psychologists think ToM is the foundation of what is unique about the human mind. Children slowly develop the full suite of ToM abilities over the first five years of age, but some of the abilities are up and running as early as nine months. While we share some aspects of ToM with our chimp relatives, other aspects are uniquely human. Chimps and children less than four can understand what others perceive, and the perceivable goals of their actions, but they can't understand that another may have a false belief. This ability in children is evident between four and five years old, when they begin to understand that what others believe may not actually be true. A full-blown ToM is needed for manipulating others' thinking, which is the basis of classroom learning. Actively teaching is a uniquely human ability.

Humans possess not only an intuitive psychology, but also an intuitive biology and physics, some aspects of which are shared by other animals, and some which are uniquely human. We humans automatically categorize whatever we run across as either an animate or inanimate object. In every society, people intuitively think about animate objects – plants and animals – in the same special hierarchical way. This intuition is the hardwired knowledge that animate objects have an underlying causal nature, or *essence*, which is responsible for their appearance and behavior. Harvard researchers Alfonso Caramazza and Jennifer Shelton claim that there are domain-specific knowledge systems

(modules) for animate and inanimate categories that have distinct neural mechanisms. These domain-specific knowledge systems aren't actually the knowledge itself, but systems that make you pay attention to particular aspects of situations in order to increase your specific knowledge. For instance, we intuitively understand that a large animal that has forward facing eyes and sharp teeth and that stalks is a predator; so, too, do other animals. We aren't born knowing what specific predator it is. If an object meets the innate criteria for the animate category and has biological motion, then we place it in the animal category and we automatically infer it has specific properties that all such things have: it's alive, it requires food and water, it can die, it has goals, intentions, and, inaccurate though it may be, ToM! This automatic bestowal of ToM on all animals is why it is so easy to anthropomorphize our pets, and why it is so difficult to believe that humans have a different psychology from other animals.

This, however, is different from how we think about inanimate objects. If something is placed in the inanimate category, a different set of properties are inferred, such as "is solid," or "won't disappear." The full extent of the intuitive physics in other animals is not known, but as Marc Hauser suggests, along with five-month-old babies, other animals must understand object permanence, otherwise if an animal didn't understand that the lion that went behind the bush is still there, there would be no prey animals left. Daniel Povinelli and Jennifer Vonk have reviewed what is known about the physical knowledge of non-human primates and have concluded that even though they can reason about the causes of observed events, they do not understand

the causal forces that underlie their observations. They appear to know by observation that fruit will fall to the ground, but they don't reason that if they are reaching for something and drag it across a hole in a table, that it, too, will fall into the void. Povinelli and Vonk suggest that humans are unique in their ability to *reason* about causal forces, and this extends to the psychological realm and is used to predict and explain events or psychological states.

Intuitive psychology is a separate domain from intuitive biology and physics. A "desire" or a "belief" isn't labeled with physical properties such as "has gravity" or "is solid," or biological properties such as "walks," "breathes," or, most importantly, "dies." This separate processing of object understanding from psychological understanding is what Yale psychologist Paul Bloom says gives rise to our "duality of experience." Humans are dualists; they act as if (and usually believe that) a person has both a physical body and another part – a soul, spirit, or "essence" that defines that person. The body, an animate object, gets tagged by our intuitive biology as something that eats, sleeps, walks, has sex, and dies. However, because the psychological part is not visible and does not have an obvious physical substance, it is subject to different inferences; "it dies" is not one of them. Humans have an intuitive belief that one's body and one's essence are separate.

Because the mental separation happens automatically, it is easy to think that either the body or the essence can exist separately, hence the concepts of a zombie, the body without the mind, or the soul, spirit without the body. Humans, unsurprisingly, have been even more creative, inventing other essences such as ghosts, angels, demons, the dev-

il, and gods or God. If Povinelli and Vonk are correct that other animals cannot form concepts about imperceptible entities or processes, and they do not possess a full ToM, then being a dualist and conceiving of such entities as spirits or God are uniquely human qualities.

Humans endlessly generate explanations and reasons for everything. My colleagues and I noticed this tendency while studying split-brain patients. The surgical procedure to cut the corpus callosum is a last-ditch treatment for patients with severe intractable epilepsy, for whom no other treatments have worked. Very few patients have had this surgery, and it is done even more rarely now because of improved medications and other modes of treatment. The treatment has been very successful, and most patients seemed completely unaware of any changes in their mental processes. Cutting the corpus callosum isolates the right hemisphere from the speech center, which usually is in the left hemisphere, so not only can the right hemisphere not communicate to the left hemisphere, it can't talk to anyone else either. With special equipment, you can give a command to the right hemisphere only. For example, you could ask the right hemisphere to pick up an apple from a bowl of fruit. The right hemisphere controls the left hand, so the patient would pick up the apple with his left hand. When you ask the patient why he picked up the apple, his speech center, in the left hemisphere, answers. The left hemisphere, however, doesn't know why the left hand picked up an apple, because it didn't see the command. This is no problem for the speech center; it will answer anyway. It may say, "I'm hungry," or "I prefer apples." In these patients, the left hemi-

sphere will smoothly make up a reason why an action, which was initiated by the right brain and of which it has no knowledge, was done.

This device, which we dubbed "the interpreter," takes all incoming information, assembles it into a "makes sense" explanation, and spews it out. It can only work with the information that it receives, and if there are gaps in this information, it is of no consequence: it will generate a story to fit the information it has. For example, in one experiment with a split-brain patient, we showed a command to the right hemisphere to laugh, and she did. When we asked her why she was laughing, instead of the left brain answering that it didn't know, she said, "You guys are so funny!" The speech center in the left hemisphere had not seen the command to laugh, but certainly was receiving the input that its person was laughing. Since that was all the information it had, it had to come up with a "makes sense" answer. It will also explain emotional states. In another experiment, we used a visual stimulus to trigger a negative mood in the right hemisphere. This time, although the patient denied seeing anything, she suddenly said that she was upset and it was the experimenter who was upsetting her. She *felt* the emotional response to the stimulus, all of the autonomic results, but her left hemisphere had no idea what caused them.

The interpreter is the device that puts all the incoming information together; it creates order out of chaos, and creates a narrative of and explanation for our actions, emotions, thoughts, memories, and dreams. It is the glue that keeps us feeling unified and creates the sense that we are rational agents. It tells our story. I propose that the left-brain interpreter is uniquely human. Receiving input from a wide variety of sources – the same sourc-

es that are available to other animals – it integrates that informational input in a unique way to create our self-conscious self, giving humans a distinct type of self-awareness that goes beyond the physical self-awareness exhibited by mirror self-recognition.

The evolutionary changes that the hominid line has undergone have brought us to our current state of being as a species, *Homo sapiens*. We share many features with our distant relatives, the chimpanzees, but we also have many unique qualities, ranging from differences in our brain anatomy (on both a macro- and microscopic level) to differences in behavior and cognition. However, the mystery remains of what exactly that change was that occurred between our last common ancestor with the chimps, and that perhaps is the founda-

tion block of our unique cognition. But neuroscientists are not alone in trying to divine ancient secrets.

There is a section in the Grand Canyon called the “Great Unconformity,” which is the surface between the rock strata called the Tapeats Sandstone, which averages 545 million years old, and the 1.8 billion-year-old metamorphic rock called Vishnu schist that it sits upon. This unconformity represents a time gap of 1.2 billion years of unknown geologic history – or about 25 percent of the earth’s history. I guess if geologists can keep plugging away at the mysteries of the 1.2 billion years missing in the geologic record, then we neuroscientists can keep plugging away at the 7 million years making up the Great Discontinuity, that unknown record of the evolution of human cognition.

#### ENDNOTES

- <sup>1</sup> Michael S. Gazzaniga, *Human: The Science Behind What Makes Us Unique* (New York: Ecco, 2008).
- <sup>2</sup> Derek C. Penn, Keith J. Holyoak, and Dan J. Povinelli, “Darwin’s Mistake: Explaining the Discontinuity between Human and Nonhuman Animals,” *Behavioral and Brain Sciences* 31 (2008): 109 – 130.
- <sup>3</sup> Natalie M. Schenker, Anne-Marie Desgouttes, and Katerina Semendeferi, “Neural Connectivity and Cortical Substrates of Cognition in Hominoids,” *Journal of Human Evolution* 49 (2005): 547 – 569.
- <sup>4</sup> There is more neuropil, the space between cell bodies that is filled with dendrites, axons, and synapses, in the left hemisphere’s speech center, in the area of the primary motor cortex designated to the hand, the primary visual cortex, and extrastriate areas.
- <sup>5</sup> See discussion in Charles Oxnard, “Brain Evolution: Mammals, Primates, Chimpanzees, and Humans,” *International Journal of Primatology* 25 (2004): 1127 – 1158.
- <sup>6</sup> Leon Festinger, *The Human Legacy* (New York: Columbia University Press, 1983), 4.
- <sup>7</sup> Oxnard, “Brain Evolution.”
- <sup>8</sup> Henrike Moll and Michael Tomasello, “Co-operation and Human Cognition: The Vygotskian Intelligence Hypothesis,” *Philosophical Transactions of the Royal Society* 362 (2007): 639 – 648.
- <sup>9</sup> Leda Cosmides, *El Mercurio*, October 28, 2001.
- <sup>10</sup> For a review, see Moll and Tomasello, “Co-operation and Human Cognition.”



- <sup>11</sup> Brian Hare et al., “Social Cognitive Evolution in Captive Foxes is a Correlated By-Product of Experimental Domestication,” *Current Biology* 15 (2005): 226–230.
- <sup>12</sup> Michael Tomasello, Josep Call, and Brian Hare, “Chimpanzees Understand Psychological States: The Question is Which Ones and to What Extent,” *Trends in Cognitive Sciences* 7 (2003): 153–156.
- <sup>13</sup> Keith Jensen, Josep Call, and Michael Tomasello, “Chimpanzees are Vengeful but not Spiteful,” *Proceedings of the National Academy of Sciences* 104 (2007): 13046–13050.
- <sup>14</sup> Jonathan Haidt, “The New Synthesis in Moral Psychology,” *Science* 316 (2007): 998–1002.
- <sup>15</sup> Mbemba Jabbi, Jojanneke Bastiaansen, and Christian Keysers, “A Common Anterior Insula Representation of Disgust Observation, Experience and Imagination Shows Divergent Functional Connectivity Pathways,” *PLoS ONE* 3 (8) (2008): e2939.